ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. T-10 - THE DESIGN AND FIT OF ARMY SHOES

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Action copies have been forwarded to Office of the Surgeon General, Occupational Hygiene Branch for approval and execution.

Project No. T-10

12 June 1945

Serial

U.S. Armored medical research laboratory,
Fort Knox, Ky.
Project no. T-10

ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. T-10 12 June 1945
SPMEA 727.3

1. PROJECT: No. T-10 - The Design and Fit of Army Shoes.

a. Authority: Oral request C/G ARTC, 10 October 1944.

b. Purpose: (1) To appraise the accuracy of shoe fitting in the Army; (2) to evaluate the criteria for proper fitting; and (3) to point out some considerations for immediate and future improvement in the utility of Army shoes.

2. DISCUSSION:

a. An abstract of data obtained from The Office of The Surgeon General, Medical Statistics Division, with regard to traumatic foot conditions in the Continental U. S. in 1943, gives the following incidence of blisters of sufficient severity to require confinement to quarters or hospital:

Approximate number of new cases admitted - 13,050
Annual admission rate per 1000 strength - 2.81
Average number of days lost per case - 6

Causative Agent:

Ill-fitting shoes	- 7375
Socks	- 70
Drilling and Marching	- 3045
Miscellaneous	- 205
Cause unreported	- 2355

b. With reference to other "Selected Diseases of the Feet," including bromidrosis, callus, clavus, metatarsalgia, trichophytosis, pes planus, etc., the following data are available for enlisted men:

Annual admission rate per 1000 strength - white - 5.610
" " " " " " - negro - 8.770
Average number of days lost per case - white - 17
" " " " " " " - negro - 18

c. However, for a complete picture of the foot disabilities, to which improperly fitted shoes contribute, it is necessary to add to the above all those cases treated at dispensaries on duty status, estimated by some to be as high as 20% of all dispensary visits, and to add further, those cases with less severe complaints whose discomfort diminishes their effectiveness without being of sufficient severity to necessitate medical attention.

d. The role which improperly fitted shoes play in the pathogenesis of trench foot has not been completely evaluated. Nevertheless, it is common knowledge that tight footgear should never be worn in the cold.

3. CONCLUSIONS:

a. A large proportion of the trainees examined at Fort Knox were fitted with shoes which were too small.

b. Existing methods of shoe fitting are often unsatisfactory. The design of Army shoes is partly responsible for this.

c. Modification of the size system and of last proportions of shoes appear to be necessary to achieve proper fitting and substantial diminution in foot disabilities among soldiers. Fundamental to this is a program of systematic anthropometry of the feet of soldiers.

4. RECOMMENDATIONS:

a. That a thorough study of foot disabilities resulting from misfitted shoes be undertaken.

b. That anthropometric measurements of soldiers' feet be secured to provide a basis for the design and fitting of Army shoes.

c. That certain recommended changes in the structural characteristics of Army shoes be given consideration.

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APPENDIX I

DISCUSSION OF THE CRITERIA FOR CORRECT SHOE FITTING

1. Army shoes may be said to be designed and fitted properly if under difficult field conditions, they are not responsible for diminishing the effectiveness of troops. The harmful effects of incorrect fitting have nowhere been studied in a controlled manner, neither by orthopedists nor by chiropodists. It is the generally held opinion that blisters, corns, bunions, ingrown nails, and certain types of cold injury probably are caused at least in part, by shoes that are too small, while lesions such as callus, foot and leg pain, and maceration of the interdigital skin, of the athlete's foot type, are more usually ascribed either to anatomic deformities or to fungus and bacterial invasion. The literature, however, both currently and in the past, has often repudiated structural explanations for many supposedly anatomical types of foot disabilities, (4,7,10,11); and a recent Air Corps report (6) indicates that many cases of interdigital maceration are cured by aeration alone. Observations on a limited number of men at the Laboratory suggest that many foot complaints may be corrected by the issue of shoes of larger size, together with proper socks.

2. The standards of shoe fitting which the Army uses (AR 850-125) are not expected to give optimal results for all individuals. The Army shoe is regarded as superior to most shoes; still, according to one competent estimate, it is perhaps appropriate for only about 70% of men. Inasmuch as the shoe is not made to foot measurements, fitting practices have to be adapted to the shoe. These fitting practices undoubtedly represent the accumulated experience of the shoe trade, and may be more or less satisfactory for the less stringent requirements of civilians. They have been adopted by the Army since no systematic evaluation of fitting appropriate to the Army has ever been made. Moreover, they involve certain compromises. One of these is the snug encasement of the forepart of the foot to avoid looseness at the throat for those individuals with low arches and small ankles. Another is the averaging of the dimensions of the two feet, in order to select an appropriate size of paired shoes. Consequently, even were shoes fitted properly according to AR 850-125, there would still be foot disabilities because of ill-fitting shoes.

3. When shoes are newly issued, judgment of the propriety of fit rests on (1) the compatibility of equivalent foot and shoe measurements, (2) on palpation of the shoe by the fitter, (3) on the sensation of the wearer, and (4) if available, on such objective criteria as the roentgenologic appearance of the foot inside the shoe. One description of an "average good fit" is that of a shoe which "fits up to the contour, but does not bind to the point of bone pressure, though it may show soft tissue compression," (7). As a definition offered by a professor of Chiropody, this is not only an indication of the highly inexact criteria which are available for the selection of shoes, but evidence that what is regarded as good shoe fitting actually may be potentially harmful to the feet.

4. Measurement: The foot measuring machines in use are not in actuality foot measuring machines. As they are at present calibrated, they give the user information only regarding the shoe size to be issued, which information may be

improper for Army use. When the side arm of the machine, if used as directed, points to a certain width, it indicates the selection of a shoe which will hug the foot closely since the measuring devices are designed on the principle of snug fit. When in addition, the sizes of the two feet, if they differ, are averaged to arrive at the size to be issued, as called for by Army regulations, the larger foot is fitted still more snugly. Finally, the measuring machine gives information only with regard to three foot dimensions, and reliance is placed on proper proportioning of the last, to assure that other portions of the foot fit in the shoe as they should. Thus, measurement across the ball gives no information regarding the dimension around the waist, across the toes, or from heel to instep of the foot.

5. Palpation: It is stipulated in AR 850-125 that the presence of excess leather across the ball is indication of a shoe which is too loose, while if the leather is too tight in that region, or if there is insufficient space beyond the great toe, the shoe is to be regarded as too small. These instructions are obviously predicated on the desirability of the practice of close fitting.

6. Sensation of the Wearer:

a. A shoe feels tight if it sensibly cramps the foot. It feels loose if the foot can slide about inside the shoe. But in making these judgments about new shoes, the soldier is not aware that new leather can be made to conform to the shape of the foot closely enough to prevent slipping, only if its dimensions are sufficiently scant to necessitate the use of force to introduce the foot into the shoe. It is also not appreciated that the sensation of pressure, or tightness, when spread over the large skin area of a structure as resilient as a foot is only perceived as such if the force is of a fairly high order of magnitude.

b. A tight shoe is obviously one which cramps the toes and ball of the foot. A loose shoe is not necessarily one in which the toes are too free. On the contrary, a loose shoe is in fact, one in which the throat fails to fit closely about the ankle. The two judgments refer to quite different categories of experience. In other words, a shoe whose forepart is abundantly large for the toes and ball of the foot, actually will not seem large to the wearer, if a means can be found to keep the ankle lacing snug, so that when walking, the sole of the shoe moves as a unit with the sole of the foot.

7. Objective Criteria:

a. Between the shoe which is sensibly too tight and the one which is sensibly too loose, there are perhaps two other degrees of fitting precision. For both of these the shoe is alleged to feel comfortable, and is worn initially with satisfaction. In the first instance, however, the soldier acquires blisters, corns, and foot pain; but for some reason the fit of the shoe is not incriminated by either the wearer or the medical officer. Not infrequently, a real or imaginary manufacturing defect will be blamed; and therapy does not usually include an increase in the size of the shoe.

b. In the second instance, the shoe also feels comfortable, and is worn under very difficult conditions with continued satisfaction. Objectively, however, it can still be demonstrated by x-ray that the shoe distorts the foot. This

phenomenon has been observed on several occasions at the Laboratory, where men have marched several hours daily, for several weeks, on a concrete track, carrying 20-lb. packs, in simulated jungle environments, while the feet and foot gear, as well as the rest of the body are continually soaked in perspiration. For these studies it has been the recent practice to issue the subject troops shoes which according to conventional standards would be regarded as oversize. Following this practice, most of the men have been able to continue marching without developing complaints referable to their feet; yet these shoes, which are initially regarded by the wearers as too large, may by x-ray be shown to be just the opposite.

8. It appears from the above that the conventional standards of shoe fitting are not altogether satisfactory for soldiers. More appropriate standards would seem to be those expressed in terms of shoe measurements which are larger than the foot dimensions for the forepart of the foot, and identical with them for the ankle region. A number of studies have been made to elucidate this principle, from which representative examples have been chosen for illustration.

a. The x-ray of the nude right foot of subject Mar (Photo 1) indicates the contour and relationship of the bony structure and soft tissue. Photo 2 illustrates the same foot encased in the service shoe (size 9D) which was issued to him at his company. This shoe, according to measurements on the Brannock device, was proper for the heel to toe length of both feet and a trifle small for the heel to ball length and the width of the left foot, but at least a size too small for these two dimensions of the right foot. By inspection alone, it may be noted that the lateral and medial metatarsals and phalanges are displaced toward the center of the foot, and the soft tissue is either compressed or displaced also. The subject was issued size 10½EE at the Laboratory, and the relationship of this shoe to his foot is shown in Photo 3. This size proved eminently satisfactory after felt padding was placed between the laces and the tongue to hold the shoe firmly to the ankle. Blisters and painful calluses, previously existent on the toes, became asymptomatic very promptly after these shoes were issued. Yet the roentgenogram in Photo 3 continues to show displacement of both bones and soft tissue, although to a lesser degree than in Photo 2. Photo 4 which is an x-ray of the same 10½EE shoe on the foot, but with the cushion-sole sock removed, illustrates the fact that the sock is not responsible for the distortion of the bony structure or the soft tissue.

b. Supplementary to the x-ray studies, plaster models were made of the foot and of the shoe interior* of another subject (Dec). This soldier was active athletically, was on his feet continuously, and was wearing a service shoe issued to him by his company, which gave complete satisfaction. Photographs of these models, Photos 7, 8, 9 and 10, and contour tracings from them (Fig. 1) illustrate the extent to which the shoe distorts the shape of the foot and vice versa. Obviously this can only happen if the foot presses against, and is pressed upon by, the shoe leather with considerable force.

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* The plaster model of the shoe interior was kept to the shape it possessed while containing the foot, by first encasing the exterior of the shoe, with the foot in it, in plaster. This rigid shoe was then used as the mold for the interior model.

9. Finally it is appropriate to present the pressure measurements above the sole on the interior of the combat boot which were made by Dr. C. P. Yaglou (12) at the request of OQMG. Pressures of approximately 1 to 5 inches of mercury were obtained, the largest pressure being in the region lateral to the 5th metatarsal, where the x-rays indicate considerable foot distortion and compression.

a. Another approach to shoe pressure measurement was attempted at the Laboratory on one subject. Strain gauges were cemented to the outside leather of four shoes sizes 9C, D, E and EE at the position of the head of the fifth metatarsal bone, and the increase in electrical resistance of the gauge wire measured for sitting and standing postures, and for walking. Consistently the pressure exerted by the foot in the shoe, causing distortion of the leather, was higher in the narrower shoe, and was higher with walking and standing with weight bearing, than with sitting and standing without weight bearing. It was not possible, however, to quantitate these observations, because the marked inequality in the stiffness of the leather of each of the shoes caused the behavior of the gauge of one shoe to differ from that of the next.

10. The feet of most men appear to possess great tolerance to misfitting; and fitting errors undoubtedly persist for this reason. In summary, several degrees of satisfactoriness in shoe fitting may be described:

a. That which is sensibly too tight.

b. That which is not sensed as being excessively tight, but which is productive of foot disability when worn.

c. That which does not produce foot disability when worn in temperate climates, but which may be demonstrated by x-rays to compress and distort the shape of the foot, and although not proved, may be contributory to foot injury in the cold.

d. That which provides abundant space for, and no pressure on, the forepart of the foot, but which is sensibly loose because of insufficient snugness at the ankle to maintain the integrity of the foot and shoe as a unit in walking.

e. That which provides abundant space for the forepart of the foot, and at the same time hugs the ankle and arch closely. Such a shoe does not now exist for most men.

APPENDIX II

SURVEY OF THE ACCURACY OF ARMY SHOE FITTING

1. Reports of improper shoe fitting in the Army are not new. A survey made by Mr. E. J. Bliss (1, 2) during the last war, in which the shoe sizes of approximately 42,000 men were checked at several camps, revealed that only 15.2% were properly fitted, while 81.7% were too short, and the remainder, or 3.1%, were too long. Still earlier, Major Munson (3) reported the experience of a colleague, who found in one series of measurements, 16.5% of shoes properly fitted, and the remainder improperly fitted--for the most part too small.

2. The present study of the precision of shoe fitting has been made on one increment of more than 500 trainees, who had just arrived at Fort Knox from reception centers where they had been issued their first Army shoes less than three weeks previously. They were therefore men who had not yet received any Army training which could be expected to change the dimensions of their feet.

3. The method of study was direct. The men's feet were measured, without socks, while standing on a double Brannock Measuring Machine. Heel to toe length, heel to ball length, and width at the ball were secured for both feet to the nearest size mark. For the heel to toe length, the measurements for the two feet were averaged as stipulated in AR 850-125, and this average was compared with the size of the shoe the soldier was wearing. The same procedure was repeated for the heel to ball length. For determining the correctness of the width fit, the dimensions recorded from the Brannock device and from the size designation in the shoe were converted into millimeters, on the basis of the Brannock scale, so that comparison could be made. An independent size scale was necessary because the letter designations of width in shoes are not finite measures in themselves, but are functions of the length dimension.

4. It is the customary practice to combine these three measurements into one expression to designate the appropriate shoe size. Since however, this procedure is purely an arbitrary one, and often misleading, the three foot measurements taken in this study were compared with the issue shoe size separately, in order to identify, if possible on which part of the foot the faults in fitting occurred. The results of these studies are tabulated and are also portrayed graphically in a series of figures. Figures 2 and 3 present the overall distribution of the measurements for each of the three right foot dimensions: heel to toe length, heel to ball length, and width at the ball.

5. In Table 1 is shown the distribution of fitting errors for heel to toe dimensions, by magnitude of size deviation from proper fit as indicated on the Brannock device. In this dimension, the prominent tendency is the issue of shoes one-half size too short, although more than 15% of the men were fitted with shoes at least a whole size too short.

Table 1

PRECISION OF SHOE FITTING
(Heel to Toe Dimension)

Deviations from Proper Size	No. of Men	Percent
3 sizes too small	1	.2
2½ " " "	0	0
2 " " "	3	.5
1½ " " "	13	2.2
1 " " "	88	15.2
½ " " "	217	37.5
Properly Fitted	183	31.6
½ size too large	66	11.4
1 " " "	5	.9
1½ " " "	2	.3
2 " " "	1	.2
	579	100.0

6. Table 2 gives the same information for heel to ball measurement. Here the discrepancy between foot and shoe measurements is much greater, the great majority of men having been issued shoes which were too short in this dimension, 30% by two sizes or more. Palpation of the shoe on the foot generally confirmed this observation, since in a great many instances the first metatarso-phalangeal joint was found to be appreciably forward of the "break" in the shoe. The reason for the marked difference between the heel to toe fit and the heel to ball fit may have been that the toe was too far forward in the shoe. This in itself may not constitute a serious error, because space equivalent to two sizes is customarily allowed forward of the toe in shoe manufacture. But this may create, in shoes of current design, a striking discrepancy in the heel to ball fitting. This, however, is not the entire explanation, since the ratio of arch to total foot length of many men is larger than the equivalent ratio for the shoe.

Table 2

PRECISION OF SHOE FITTING
(Heel to Ball Length)

Deviations from Proper Size	No. of Men	Percent
3½ sizes too small	4	.7
3 " " "	15	2.6
2½ " " "	60	10.4
2 " " "	105	18.1
1½ " " "	155	26.8
1 " " "	130	22.5
½ " " "	78	13.5
Properly Fitted	29	5.1
½ size too large	2	.3
1 " " "	1	.2
	579	100.2

7. The fitting of the ball of the foot too far forward in the shoe has two important effects. It causes the ends of the toes to be placed in the tapered part of the shoe, where they may be displaced or compressed by insufficiency of upper leather circumference (Fig. 4, Photo 2). Perhaps more importantly, the broadest part of the foot is thus improperly placed forward of the widest part of the shoe. The discrepancies in width fitting which are shown in Table 3 are therefore more serious than the data immediately imply, since to the extent that the toes are placed in the tapered part of the shoe, they fail to obtain full advantage of its maximum breadth.

8. The data in Tables 1, 2 and 3 are portrayed graphically in Figure 5. In summary, it appears that the sizes of shoes issued are in general considerably smaller than is stipulated by the fitting manual AR 850-125 even when the feet are measured without socks. Heel to ball and width dimensions are most often improperly fitted, the heel to toe dimension being fitted incorrectly less frequently and to a lesser degree.

9. a. These evidences of misfitting by no means present the entire picture. The foregoing observations have been based on comparison of the size designations in shoes with those on the measuring device, on the premise that both represent equivalent dimension systems. This is far from true. Measurement of 57 pairs of service shoes, reverse upper, reveals that the shoe dimensions are consistently smaller than the Brannock size system implies. Inasmuch as the Brannock measurement is an approximation of the foot size, even were the "proper" shoe sizes issued they would still be too small. The extent to which the dimensions of the measured shoes were smaller than Brannock dimensions is shown in Table 4. It is noted that the larger shoe sizes consistently vary by the largest amounts from the size indicated on the measuring device.

Table 3

PRECISION OF SHOE FITTING
(Width at Ball)

Deviations from Proper Size (mm.)	No. of Men	Percent
>12 mm. too small	6	1.0
12 " " "	4	.7
11 " " "	5	.9
10 " " "	5	.9
9 " " "	17	2.9
8 " " "	14	2.4
7 " " "	20	3.5
6 " " "	50	8.6
5 " " "	46	7.9
4 " " "	33	5.7
3 " " "	108	18.6
2 " " "	54	9.3
1 " " "	53	9.2
Properly Fitted	58	10.0
1 mm. too large	23	4.0
2 " " "	17	2.9
3 " " "	26	4.5
4 " " "	7	1.2
5 " " "	17	2.9
6 " " "	4	.7
7 " " "	5	.9
8 " " "	4	.7
>8 " " "	3	.5
	579	99.9

b. These 57 pairs of shoes were manufactured by 22 different concerns. Inspection of the measurements reveals that the size discrepancies do not indicate errors in manufacture, but rather that they represent (1) defects in the plan of systematic shoe sizing, and (2) failure of the measuring device to correspond to the shoe sizing plan. It was noted moreover, that in only 45 or 77% of the pairs of shoes were the rights and lefts of approximately identical size. In the other 23% the rights differed from the lefts in either length or width by amounts of from 3 to 7 mm.

10. a. In the opinion of those who conducted the fitting study in 1918 (2), the reasons for fitting errors were: (1) lack of experience on the part of the fitters; (2) ignorance and vanity of the soldiers being fitted; (3) discrepancy between the shoe size designation and its actual dimensions; (4) incomplete stocks of sizes leading to substitutions; and (5) fitting on the basis of civilian conditions of use.

b. At the present time it is believed that different reasons should be assigned. Foremost are the failure of fitters to issue shoes according to the measuring device, and the failure of the measuring device to agree in size dimensions with the shoes. The former difficulty may be due in part to the haste with which fitting is accomplished. Of importance also are the inappropriateness of the design and shape of the shoes for the feet of soldiers who spend much of their time standing or walking, and the inappropriateness of conventional civilian fitting standards for Army conditions of use. These reasons are regarded as basic. It is believed that soldier resistance to proper fitting derives from failure to establish more satisfactory fitting standards in the past.

Table 4

EXTENT TO WHICH INTERIOR WIDTHS OF 57 UNUSED SHOES, SERVICE, REVERSE UPPER, SELECTED AT RANDOM, WERE SMALLER THAN EQUIVALENT DIMENSIONS OF BRANNOCK MEASURING DEVICE*

(Differences are in Millimeters)

	B	C	D	E	EE	EEE	EEEE
6				-5		-8	
6½			0	-5	-8		
7			-5	-4			
7½			-1		-9		
8				-6	-9	-11	-17
8½				-8 -7	-11		
9		0	-3	-7	-11	-15	-18
9½		-1			-11		
10			-5 -4	-8 -8	-10	-15	-21
10½		-3	-5		-10		
11		-3	-7	-8	-13	-16	-19
11½		-6		-8			
12	-4	-5		-11			
12½	-1	-4	-7	-10			
13	-2	-3 -5	-10 -7	-12			
13½			-11	-12			

*Width of shoe interior determined by measuring maximum exterior width approximately ½ inch above sole, with calipers, and subtracting 4 mm. for thickness of the leather. In measuring, the side walls of the shoes were held in position parallel to each other and perpendicular to the sole.

APPENDIX III

REMEDIAL MEASURES APPLICABLE AT PRESENT

1. Experience has accumulated at the Laboratory on approximately 35 unselected soldiers to indicate that in most instances men can wear the existing service shoes in hot or temperate environments, without developing blisters, callus, corns, ingrown nails, or painful feet, when the shoes are properly fitted. On the relatively infrequent occasions in which such lesions have developed, they have promptly healed without change in the subject's activity, when a still larger size shoe was issued.

2. The fundamental requirements for successful shoe fitting which have evolved as a consequence of these studies are:

a. Conscientious measurement of the foot by an interested individual who is encouraged to take sufficient time with each soldier.

b. Development of a measuring device which corresponds to Army shoe sizes.

c. Modification of the regulations for the use of measuring devices.

d. Frequent checking of new shoes and of rebuilt shoes for accuracy of sizing.

e. An adequate supply of shoes in the size range needed.

3. From the experience at the Laboratory it appears that size tariffs based on contemporary Army experience are unreliable inasmuch as the Army practice has been to issue shoes which are too short and too narrow. Furthermore, for shoes of proper size to be available at all times, it is probable that shoes should be issued only at a central depot, and never at the company supply room. Only in this way would all sizes be available, and all shoes be issued under the supervision of a trained fitter.

4. Substitutions of size, when necessary, should always be in the direction of increased width. Issue of a shoe of shorter length than indicated on the measuring device should never be attempted, since in present shoe design, width decreases with length: e.g. a 7D shoe is both shorter and narrower than a 7½D shoe. Space must always be allowed in front of the small toe, because of the sharp radius of curvature of the front of the shoes, and because the arch of the upper leather over the toes causes the interior space of the top of the shoe to be smaller than the sole dimensions indicate. This is illustrated in Photos 4, 5 and 6, which portray respectivly subject Mar's foot without a sock in a shoe of size 10½EE, the same foot in the shoe with the toe leather cut away, and the same foot again resting on the sole of the shoe with the entire upper leather cut away. It is apparent in Photo 6 that the undistorted foot occupies the entire tread of the shoe, overlapping the space reserved for stitching. In Photo 4, where the upper leather is present, the phalanges and soft tissue are displaced. The proper size for this individual whose foot is by no means unique, would probably be 10EEE, or 10EEEE, the 10½ having been selected so that more of the forepart of the foot might fit in the part of the shoe proximal to its tapered toe. The x-ray is slightly misleading in one respect.

Actually the tread of the foot, or that area of the sole which rests on the ground, does not occupy the entire sole surface of the shoe. This is illustrated in contour tracings of plaster models of the foot and shoe (Fig. 1) and in an overlay tracing of the tread imprint and x-ray of another subject (Dec) (Fig. 4). It is seen that the diameter of the sole which is in contact with the ground is actually about a half inch narrower than the shoe sole pattern appropriate for this foot as determined by measurement on the Brannock device. The reason for this is that the broadest diameter of the foot is not at the tread but approximately one-half to three-quarters of an inch above the ground surface.

5. More successful fitting of current shoes would probably be achieved if emphasis were placed on the heel to ball length of the longer foot, when the ball and toe lengths are averaged, as the measurement of principal importance. With this average for the length, the width then appears to be best determined by adding one unit to the indicated dimension of the wider foot. This will give good results for most individuals, although some with unusual foot shapes will probably require trial and error fitting, and some will not be fitted at all. By this procedure all will be fitted large according to contemporary conceptions of fit, since the leather across the ball will be loose. The selection of the larger foot for fitting is important, since the difference in the dimensions of the two feet sometimes is appreciable, often amounting to an entire size in length and an eighth of an inch in width. Deviations of greater magnitude than this are not infrequently encountered. The distribution of the differences in the size of the two feet is shown in Figure 6. Contrary to general opinion, it appears that neither the right not the left foot is consistently larger than its mate.

6. Modification of the existing fitting regulations implies:

a. Complete disregard of the soldier's desires as to size. His civilian shoes were probably too small, and his demand for his conception of a proper fit will lead to the rejection of a more appropriate shoe which may seem loose because the incompletely resilient new leather does not initially hug the foot, or because the throat cannot at first be laced to the ankle and arch as desired. Stiffness of upper leather may improve the appearance of new civilian shoes; but it adversely influences the fitting of Army shoes. It has been the experience at the Laboratory that soldiers are very difficult to convince concerning the requirement for shoes larger than they have been accustomed to wear. For a few individuals demonstration of the x-ray comparison of the nude foot and the shod foot have been helpful. It might prove advantageous to display photographic reproductions of such x-rays in fitting rooms and in training manuals.

b. The realization that the feet to be fitted may be structurally normal, structurally abnormal, or functionally abnormal due to shoes improperly fitted in the past. This rarely is apparent to the fitter, since he does not see the soldier's foot without socks on. And if he did, he would not be professionally competent to act on his observations. A trained chiropodist at the fitting station could save many dispensary visits later; but for his services to be effective, both time and space are needed at the reception center.

7. Finally, with regard to the number of socks to be worn inside the shoe, the proper procedure to be adopted is difficult to ascertain. In cold weather, wearing an excessive number of socks inside shoes not fitted for them increases the

sensation of cold and may be dangerous. Possibly oversize shoes should be issued for winter wear. When shoes are fitted, the practice of wearing an extra pair of socks for that occasion only, offers little advantage. The measuring device is not sensitive enough to detect a change in the foot size with any but the heavier sock combinations, as shown in Table 5. And the soldier whose shoe is fitted over two pairs of socks complains that the shoe is too large, when one of the socks is removed.

Table 5

COMPARISON BETWEEN THE SHOE SIZE REQUIRED FOR THE UNCOVERED FOOT AND FOR THE FOOT COVERED WITH VARIOUS SOCK COMBINATIONS*

	LEFT FOOT			
	Heel to Toe Shoe Size	Heel to Ball Shoe Size	Width (mm.)	Circumference at Ball (mm.)
Nude Foot	9	10½	94	241
Cotton Sock	9	10½	94	-
Light Wool Sock	9	10½	94	243
Cushion Sole Sock	9½	10½	94	245
Cushion Sole Sock (2 pr.)	9½	10½	97	-
Ski Sock	9½	10½	98	-

* Measurements made on Brannock device

8. By following a program such as the above, proper fitting for the forepart of the foot can be obtained. The shoe so fitted may seem large to the wearer, however, if the sole of the shoe fails in walking to move as a unit with the sole of the foot. As pointed out previously, this seems to be due to looseness in the dimension from the heel to the instep, the lacing of the shoe failing to secure a close fit around the ankle. This is a manifestation of a defect in last design, the heel to arch dimensions being excessive in proportion to the width and length. This difficulty will be experienced least frequently by soldiers with high arches, and most frequently by those in whom the slope of the superior metatarsal surface is shallow. Size compromises on this account in the past, are in all probability an important reason for the contemporary practice of misfitting with small shoes.

9. There are three expedients conceivably available for making such shoes fit the ankle better. One is to place a piece of felt 2 x 5 x ½ between the lacing and the tongue of the shoe to provide additional thickness against which to tighten the laces. The second is the use of the so-called French Marching Strap, which is nothing more than a figure of eight strap around the ankle and instep (13). And the third

is the universal adoption of the boot, combat, tropical, with flexible nylon uppers, with an increase in the space between the lacing stays, or some other method of closure, to allow greater universality of fit. The usefulness of the last proposal has not been tested. (A modification of the marching strap should prove useful on shoe-pacs, the fit of which, even with extra socks, is not always snug enough for comfortable marching).

10. A segment of the experience of the Laboratory in fitting shoes is illustrated in Table 6. In every instance the measurements of the nude foot called for a larger shoe than the subject had been wearing; and in most cases, a still larger shoe than the measurement called for was issued. In the four instances in which minor foot complaints developed, they subsided with no other treatment than the issue of a shoe of yet greater size.

11. It has been frequently asserted that feet change in size with training. It cannot be ascertained at the present time that this is an important consideration in the fitting of shoes. Full development of the foot usually has been achieved by the time even the youngest recruit becomes a soldier (14, 8), so that the only change that could occur would be due to (1) alteration in the amount of subcutaneous tissue, (2) altered spacing of the toes, or (3) flattening of the arches. With regard to the first, flesny feet conceivably may become more slender as a consequence of loss of subcutaneous fat, but slender feet are not likely to enlarge as a consequence of muscular development, since there is actually very little muscle tissue in the foot. Concerning the second, increased spacing of the toes would not alter the selection of the shoe size since the toe dimensions do not enter into the choice of the shoe, the broadest part of the foot usually being posterior to the toe region. Finally flattening of the arch can add very little to the measured length or breadth of the foot beyond that which occurs with standing, which is the posture in which measurements are taken. Depression of the astragalus and scaphoid does increase the circumference at the instep, or shank, but service shoes are not made to accommodate this deformity in any case (Appendix IV). The size of the foot tread increases in length with each step as compared with the standing size, but the foot tread is not taken into account when feet are measured.

a. Studies of the change in foot size of troops are shown in Figure 7 wherein the results of remeasuring the feet of 389 of the soldiers, whose feet were initially measured soon after induction, are presented. The repeat measurements were made after 17 weeks of basic training at Fort Knox. The changes for both the right foot and left foot are shown for each of the three measurements taken: heel to toe, heel to ball, and width at ball. It appears that many of the men show no change in foot size, that about a fourth show an increase in heel to toe length of $\frac{1}{2}$ size, and that changes in heel to ball length and in width are equally divided between increases and decreases. Those in whom changes in width occurred did not change for the most part more than 3 mm. (1/8") plus or minus. As mentioned, the significance of these size changes is not fully understood, but perhaps for the individuals who do manifest size changes of a substantial nature, it would be proper to refit all individuals at the time of completion of basic training, or earlier, if indicated.

Table 6

EXPERIENCE IN FITTING SHOES TO TROOPS
MARCHING IN A HOT ENVIRONMENT

Name (1)	Service Shoe Size Customarily Worn (2)	Shoe Size Determined By Brannock Device According to AR 850-125 (3)	Shoe Size Issued at Laboratory (4)	Subsequent Change in Shoe Size (5)
Abe	8½E	10D	10EE	
Atw	9B	10D	10E	
Bud	9C	9½D	9½D	
Buz	11C	11½C	11½C	
Del	11C	14C	12E	12½E
Ger	9EE	10½C	10½D	
Har	9½B	10C	10D	
Koz	8½E	10D	10½E	
Mar	9D	10E	10½D	10½EE
Nor	9½D	11E	11E	
Roh	7½EE	9E	8½EE	
Tho	9½B	10C	10C	10D
Tol	9½D	11C	11C	
Tul	9D	10½E	11D	
Zim	9½B	10D	10D	10½D

Column-Headings:

(1) Subjects were representative Fort Knox Troops.

(2) The size of shoe worn by the men when the troops reported to the Laboratory.

(3) Size of shoe indicated by Brannock device as proper for bare feet.

(4) Size of shoe issued to accommodate one pair of heavy cushion-sole socks.

(5) Subsequent changes in shoe size which successfully permitted improvement of blisters and painful callus without interruption of marching schedule.

b. Misfitting with shoes which are too small may actually influence the dimensions of men's feet, although this, in itself, is no indication that casualties will be produced thereby. Of the group of men whose feet were remeasured, the breadth of the right foot before and after basic training has been compared. Those individuals who showed no change in foot dimensions, or an increase or decrease only in this dimension were then separated into two groups--those whose shoes were properly fitted initially and those whose shoes were initially too narrow. The results of this comparison are shown in the following table:

Table 7

INFLUENCE OF INITIAL SHOE WIDTH ON CHANGE IN FOOT WIDTH
OVER 17-WEEK BASIC TRAINING PERIOD

	Shoes Fitted* Properly		Shoes too* Narrow	
	No.	%	No.	%
No change, or increase in foot width	70	80.5	52	56.0
Decrease in foot width by 2 mm. or more	17	19.5	41	44.0
	87	100.0	93	100.0

c. Of those individuals whose shoes were fitted properly, only a small percentage experienced a decrease in foot breadth, while diminution in the width of the foot was noted in almost half of those fitted with too narrow shoes. The differences are regarded as significant.

d. The effects of short marching periods on foot size were also studied. In Table 8 is shown the mean change in foot size of 14 men after a period of 6 weeks' marching in a hot environment during one of the hot room experiments at the Laboratory. Table 9 shows the mean variations in foot volume of 8 men, measured by overflow plethysmography, observed at scattered intervals during another hot room experiment. Finally Table 10 shows the volume change associated with cooling of the dependent foot for 7 subjects whose bodies were otherwise warm. In none of these observations is the pattern of size-change sufficiently impressive to justify any conclusions with regard to its effect on shoe fitting.

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* Shoes were regarded as fitted properly if the toe length was no more than ½ size too short, the width no more than 3 mm. too narrow, and the ball length no more than 1 full size too short.

Shoes were said to be fitted too narrow if the width was more than 3 mm. narrower than called for by measurements, or if the ball length was more than 1 size too short. The latter criterion was introduced since a short ball length forces the foot forward into the tapered part of the shoe.

Table 8

DIMENSIONS OF MEN'S FEET BEFORE AND AFTER A PROTRACTED WALKING EXPERIMENT IN A HOT ENVIRONMENT

(Dimensions are expressed in millimeters.
Mean of 14 men)

	Heel to Toe Length	Heel to Ball Length	Width at Ball
Right Foot - Before	276	202	102
" " - After	276	204	101
Left Foot - Before	275	202	102
" " - After	275	201	100

* The subjects wore shoes of adequate size. Their bare feet were measured on the double Brannock machine while standing. The hot room experiment obliged the men to walk 12½ miles daily, 6 days a week on a concrete track carrying a 20-lb. pack, at temperatures approximately 93° DB, 91° WB, 93% RH.

Table 9

EFFECT ON LEFT FOOT VOLUME OF WALKING IN COOL AND IN HOT ENVIRONMENTS

(Mean of 8 men)*

	Left Foot Vol. cc.
At Start of Experiment	1155
7th Day of Marching in Cool Environment:	
Before March	1137
After March	1151
1st Day of Marching in Hot Environment:	
Before March	1160
After March	1169
11th Day of Marching in Hot Environment:	
Before March	1148
After March	1177

* The subjects wore shoes of adequate size. Measurements were made while the subjects stood with the left foot bare in an overflow type of water plethysmograph.

Incl. #3

Table 10

CHANGE IN FOOT VOLUME WITH COOLING*

(Data are in cc. of change)

Subject	Cooled Foot	Uncooled Foot Control
1	+20	+40
2	+10	+20
3	-15	+25
4	-20	+20
5	+15	+20
6	-15	+15
7	0	-10

*Procedure: Subject sat in comfortable environment, while one foot was immersed for 90 min. or more in a cold air chamber, while the companion foot remained outside the chamber, but at approximately the same level of dependency. Measurements of volume were made before and after cooling with an overflow-type of water plethysmograph while the subject remained seated.

APPENDIX IV

THE DESIGN OF A NEW ARMY SHOE

1. The need for a change in the Army shoe last has been expressed by many, but there has yet to appear any more systematic information than was available for the design of the shoe and last in current use. It is a mistake to suppose that changing the last will correct the present errors in shoe fitting. These derive only in part from faulty shoe design; faulty methods of issuing them are undoubtedly of prominent importance. If the present system of distributing shoes is permitted to continue, no modification of the last can be expected to accomplish the desired improvement. It is well in this connection to recall Munson's experience (5). On one occasion he tested three new shoe modifications on a march of 117½ miles, in which 379 men participated. Not one of the men failed to finish the march on account of foot trouble, although a few fell out for other reasons. Munson explained that this did not mean that all of the lasts were equally satisfactory, but rather that all of the shoes were properly fitted. There are, nevertheless, certain refinements of the present shoe which would be desirable, both with regard to the last and with regard to the shoe structure proper.

2. Changes in Last Design. Basically, for the shoe to fit properly, there is required only a broad enough sole for the foot to rest on, and straps to secure the sole to the ankle, as in the case of mukluks. It is believed that it is not necessary to wedge the forepart of the foot into the front of the shoe in order to secure a satisfactory fit.

a. Circumference at the Throat. There is required a fundamental change in last proportions to obtain a shoe which fits securely at the ankle while affording abundant space for the metatarsals and phalanges in the forepart of the shoe. Advantage in this regard might be gained by the use of a more resilient type of upper material and a different type of closure at the throat.

b. Circumference across the Ball and Toe. The upper leather of the vamp and toe arches from one side of the sole to the other with the result that the interior shoe breadth a half inch above the sole, at approximately the point of the greatest thickness of the foot, is not as wide, or no wider than the dimension across the sole proper. Thus if space is available on the sole for only slightly more than the breadth of the tread, the dorsal thickness of the toes is not provided for. The manufacture of shoes on the principle that the foot is a relatively amorphous mass, which can be accommodated if sufficient cubic volume is made available inside the shoe, is the basis of this difficulty. Evidence that this principle plays an important role in last manufacture is the fact that the present critical last measurements are the circumference of the ball, waist, and instep, the systematic grading of which on automatic lathes, actually determines the size of the shoe. The effects of this practice are seen in Figure 1. Here are shown full scale tracings of the contours of the toe segment, ball, waist, and instep of the plaster models of a foot and of the interior of its shoe, pictures of which appear in Photos 7, 8, 9, and 10. From these tracings and from the photographs it is apparent that circumference measurements by no means express the shape requirements of a properly fitted shoe. What is required is the con-

struction of a shoe whose sole is as broad as the thickest part of the foot over it, and whose upper leather is shaped to accommodate the dorsal as well as the ventral toe and ball diameters. Only in this manner is it possible to prevent displacement of the toes such as shown in Photo 2.

c. Tapering of the Toe, with Excessive Curvature of the Tip. Combined with the arching of the leather over the toe, the present shoe shape has the effect of confining the toes. This effect can be minimized with present shoes, only by issuing an otherwise needlessly long shoe, in order to provide space for the small toes (Photo 3).

d. Indentation of the Medial Surface of the Shoes at the Instep or Shank. Marked shaping of the upper leather at the shank, to provide a close fit under the arch, appears to have no fundamental value. The need for "support" of the foot at this point has never been demonstrated. It is, on the other hand, a distinct hindrance to the fitting of individuals whose astragalus and scaphoid bones are depressed, who have, in other words, "flat feet" in an anatomical though not in a functional sense. Reasoning from the pain produced by the ill-advised prescription of arch supports to these individuals, it is not unlikely that the shaping of this segment of the shoe may be similarly productive of pain. Indeed the error is not infrequently made of prescribing arch supports to go into shoes which were too small before their introduction.

e. Proportion between Heel to Ball and Ball to Toe Length. Figure 8 indicates the distribution of these foot dimensions. It is apparent that the ratio between them is by no means constant, but on the contrary is spread over a wide range. Surprisingly, the coefficient of correlation between the heel to ball length and the ball to toe length for 579 men is -.44, indicating primarily, negative relationship. To accommodate individuals whose toes are disproportionately long in relation to their other foot dimensions, present shoes have a long toe segment. This imposes on some men a disadvantage in walking, since the long toe segment of the shoe sole acts as a lever, dorsiflexing the toes to a greater degree than is necessary, with each step.

f. Width. Present lasts provide a shoe whose broadest diameter is at the ball. It is not necessary to measure many feet to observe that in a large number of individuals, the broadest diameter of the foot is forward of this point.

g. Heel Breadth. Last design being predicated on the systematic increase of every dimension with every other one, causes the diameter of the heel to become larger with augmention of the circumference at the ball. A limited number of observations on men's feet suggests that this practice does not correspond to the proportions of the human foot. Figure 9 indicates that the heel-breadth dimension does not vary greatly, regardless of the variation in the breadth at the ball. It is probable that this is of little importance, except in principle, since the heel breadth of the shoe need not conform to that of the foot, provided that it is larger.

3. Anthropometry of Soldiers' Feet. These considerations strongly indicate the need for a series of accurate soldiers' foot measurements before new lasts are designed. Methods for performing such a task accurately and expeditiously seem

not to have been developed heretofore and no such measurements have ever been made. However, they are under development at the Laboratory at the present time. The present last dimensions were established by a committee of shoe men in 1886, who accomplished their task in a series of conferences. These same last dimensions are still in use, having been altered only in minor respects, and in a purely arbitrary manner. Table 11 indicates the dimension increases which have been made in the Munson last over the civilian size standard as outlined in the booklet of size standards published by the Vulcan Corporation (9).

Table 11

DIFFERENCE BETWEEN MUNSON AND CIVILIAN LAST DIMENSIONS

Girth at Ball	- Plus	1/8"
" " Waist	- "	2/8" (A width + 3/8")
" " Instep	- "	2/8"

4. Current Last Dimensions.

a. Table 12 shows the heel to toe, heel to ball, and width at ball dimensions of part of the size range, as they appear when converted into millimeters from the Brannock measuring device. As pointed out in Appendix II, this is not a true representation of the Army size scale, but the table serves to illustrate the fact that the size differences are quite systematic. Where this does not appear to be so, it is because the conversion of inches and portions thereof to the nearest millimeter causes some distortion of the pattern. The explanation offered by shoe men for this system is that the provision of so many sizes and part sizes which result from making the width change with length, makes available a shoe size for every wearer. In fact, somewhere in Army Depots may be found shoes from size 3 to 15, and from width AAA to EEEEEE. If all sizes and half sizes were available in all widths, there would exist 284 sizes from which to choose. The fallacy, of course, is that feet do not follow such a systematic pattern of size increase. Whatever success is achieved from present fitting practices must derive in great part from the apparently great tolerance of feet for shoes of improper size.

b. It seems not unlikely because of this tolerance for shoes of inaccurate fit that when a large number of foot measurements become available, for proper proportioning of shoes, more satisfactory fitting may be achieved with a greatly reduced inventory of sizes. Essential to this, however, is a modification of the code for indicating the sizes of shoes.

Table 12

DIMENSION OF SHOE SIZES ADAPTED FROM A SEGMENT OF THE BRANNOCK DEVICE

(Sizes are in Millimeters)

Size	Toe mm.	Arch mm.	W I D T H mm.					
			A	B	C	D	E	EE
7	251	180	77	82	86	91	95	100
7½	255	183	79	83	88	92	97	102
8	260	185	80	85	89	94	98	103
8½	264	188	82	86	91	95	100	105
9	269	191	83	88	92	97	102	107
9½	273	194	85	89	94	98	103	108
10	278	196	86	91	95	100	105	110
10½	282	199	88	92	97	102	107	112
11	286	202	89	94	98	103	108	113

5. Change in Size Nomenclature. An urgent need is a revision of the system by which sizes are designated. A soldier's resistance to proper fitting often rests upon his desire to obtain a size 7C if his civilian shoe size was 7C, regardless of the fact that the dimensions of the Army shoe may be entirely different from those of the civilian. It would appear to be far more satisfactory from many points of view, as indicated below, if the length, breadth, and other dimensions of the foot to be fitted were indicated in the shoe in metric units. Thus a shoe to fit a foot 30 cm. long and 9 cm. wide would be designated as 30-9.

6. Alteration in shoe lasts would provide an opportunity for making other revisions in shoe structure which, it is believed, would contribute materially to their general usefulness.

a. Rocker Action. Current shoes are made to rest almost flat on the ground when new. After being worn they invariably turn up at the toe to a greater or less degree (Photo 7). Since this apparently has little effect on the satisfaction with which the shoe is used, no harm should result from the adoption of such a shape as standard. The advantage gained would be the shortening of the upper dimension, longitudinally, from toe to vamp, with less likelihood of the vamp leather creasing, a not infrequent cause of abrasion on the tops of the toes.

b. Dissipation of Sweat in the Toe Region. It has been demonstrated by the Army Air Forces Board (6) that maceration and interdigital infection of the toes may be cured by wearing sandals. The most obvious explanation is that the toes are permitted to spread, so that air may circulate between them, dissipating moisture instead of permitting it to accumulate. It would seem possible to develop a fabric for the toe box of the shoe which would be water repellent but vapor permeable, and which, in a shoe with sufficient toe space, might very likely lower the incidence of athlete's foot.

c. Insulation of the Sole. In the manufacture of Army shoes there is space between the inner and outer sole which is occupied by the filler. It is suggested that this space might be increased in thickness, and that it might be filled with material of higher insulation value than the material which is used at present. A modification of this nature would be advantageous for both hot and cold environments.

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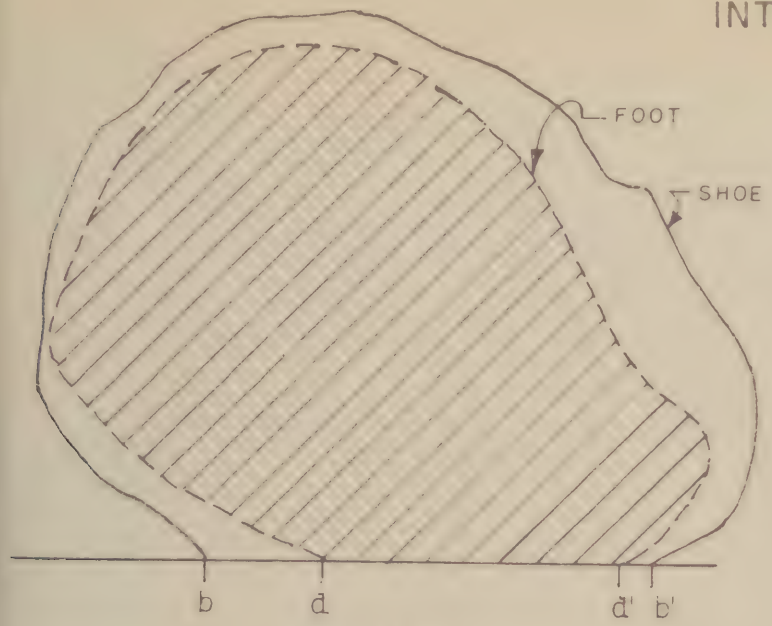
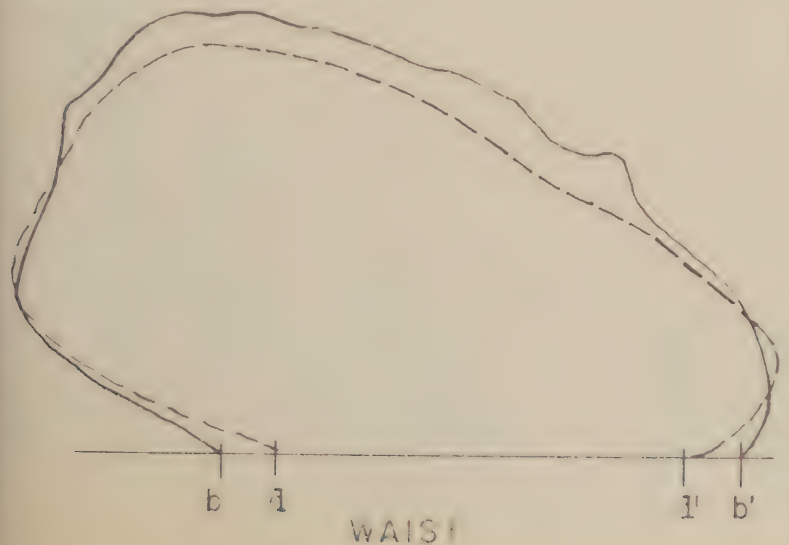
FIG. 1

CONTOUR TRACINGS OF PLASTER MODELS OF UNSHOD FOOT AND OF INTERIOR OF ITS SHOE

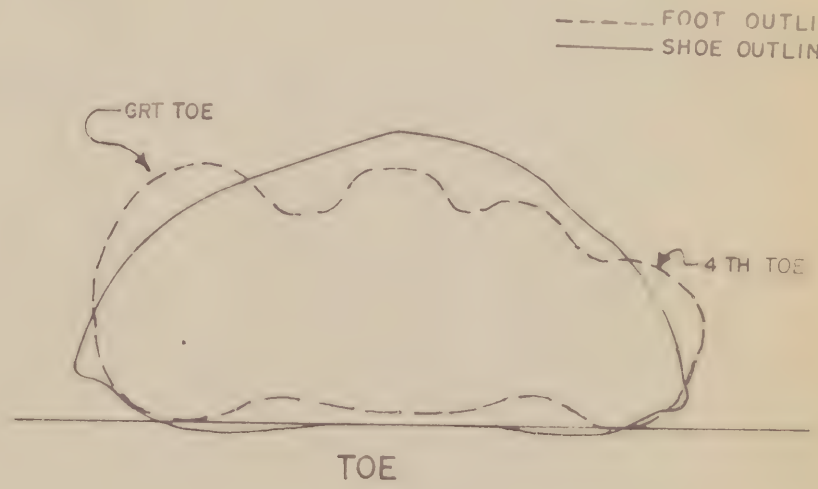


INSTEP

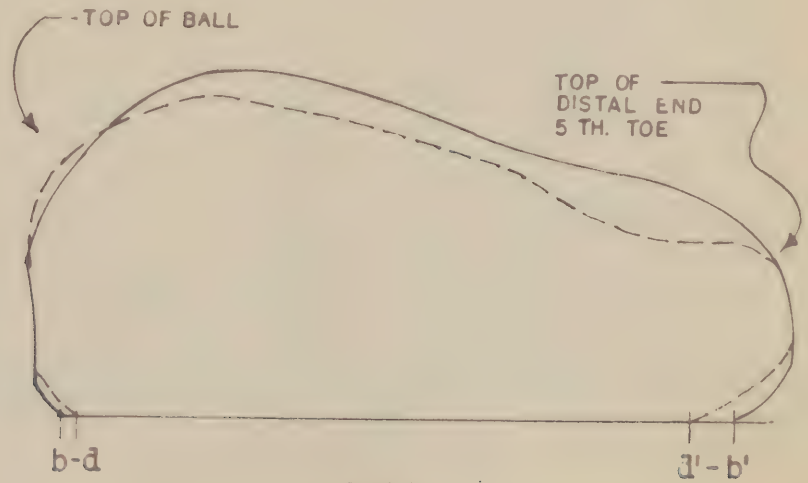
d - d' - BREADTH OF FOOT IMPRINT
b - b' - BREADTH OF SHOE SOLE



WAIST



TOE



BALL

FIG. 1

FIG. 2

DISTRIBUTION OF DIMENSIONS OF MEN'S FEET

(RIGHT FOOT)

579 MEN

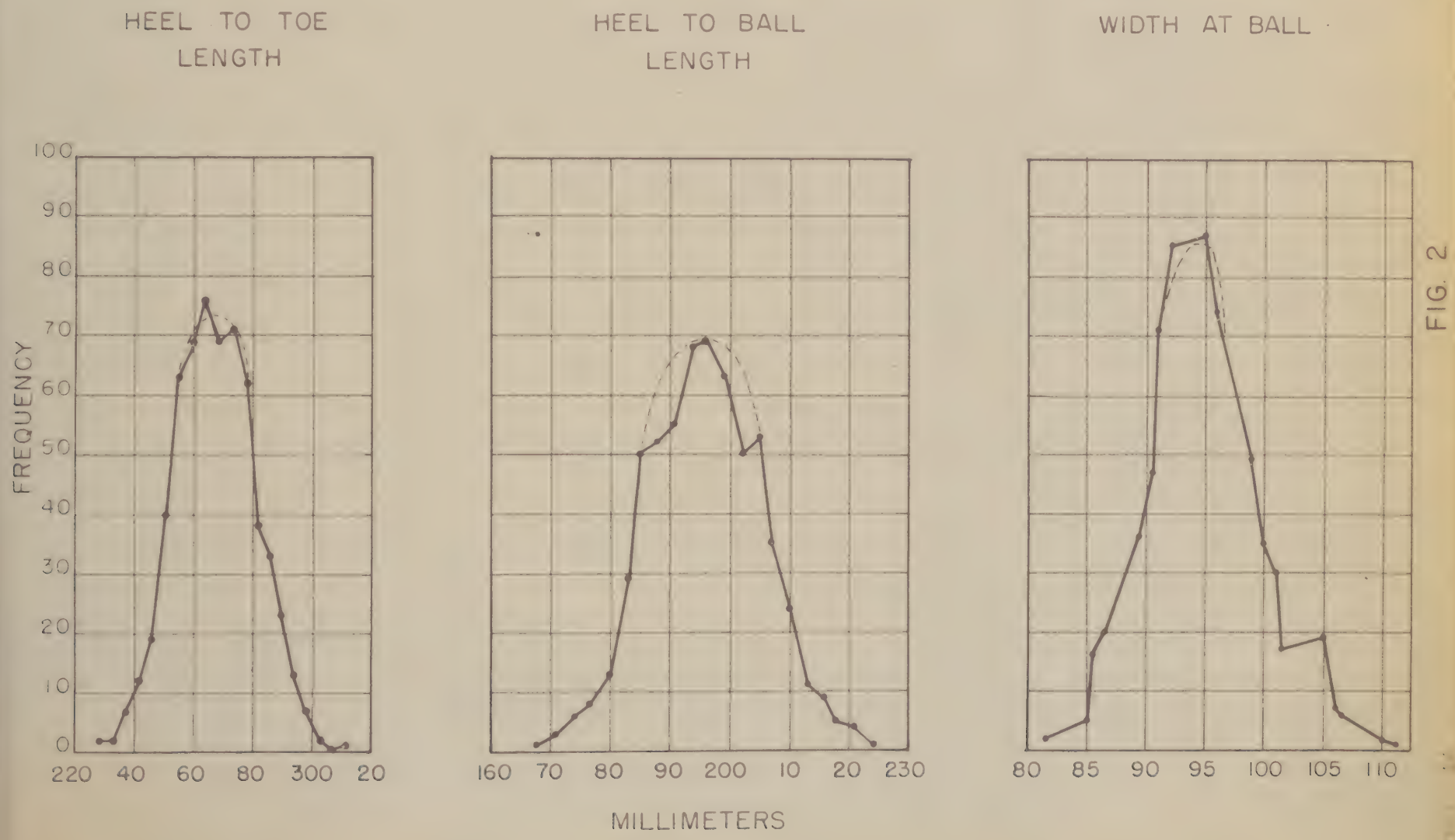


FIG. 2

DISTRIBUTION OF DIMENSIONS OF MEN'S FEET

(579 SUBJECTS - RIGHT FOOT ONLY)

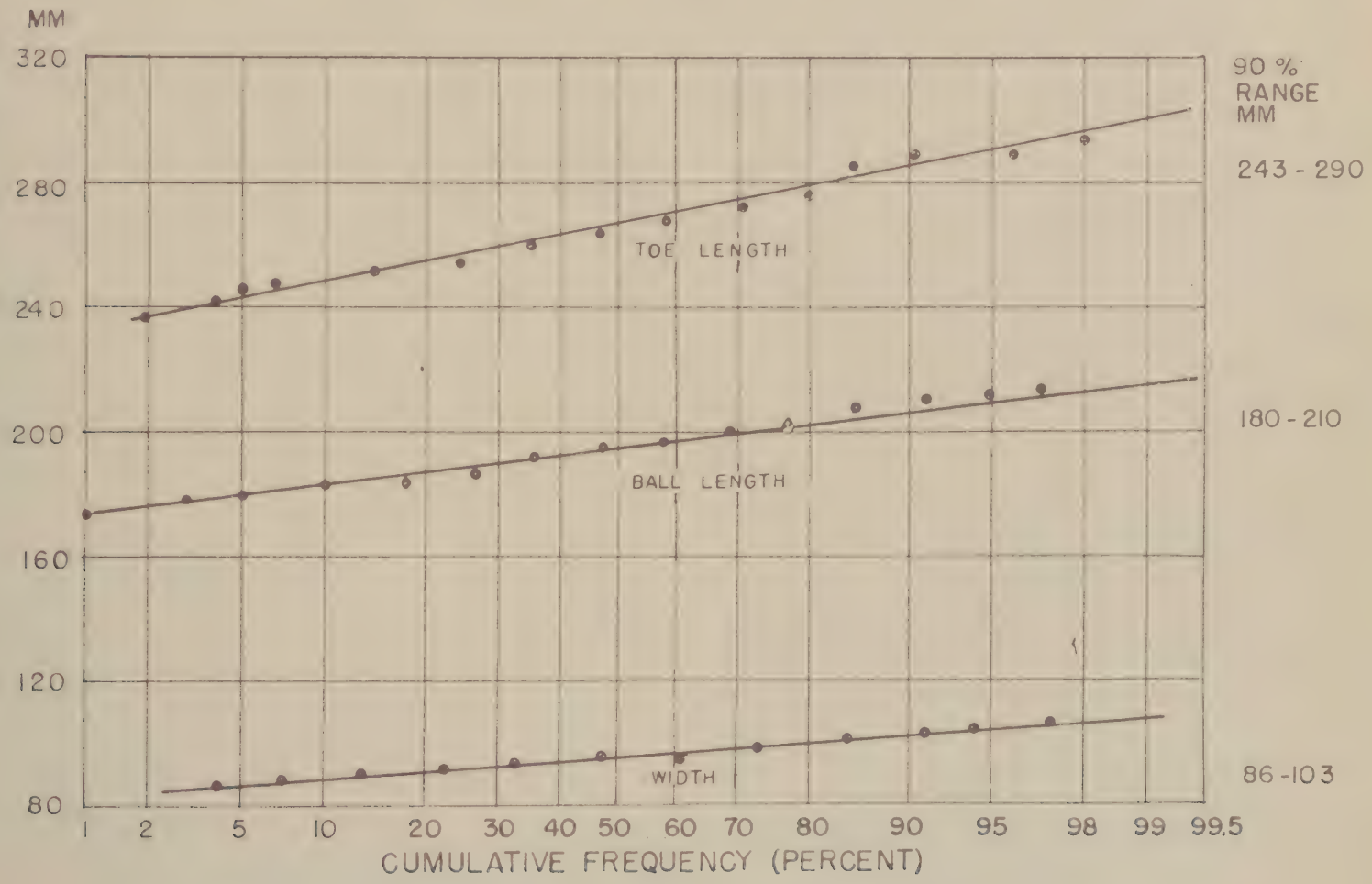


FIG. 3

FIG. 4

CONTOUR OF FOOT INSIDE AND OUTSIDE OF SHOE

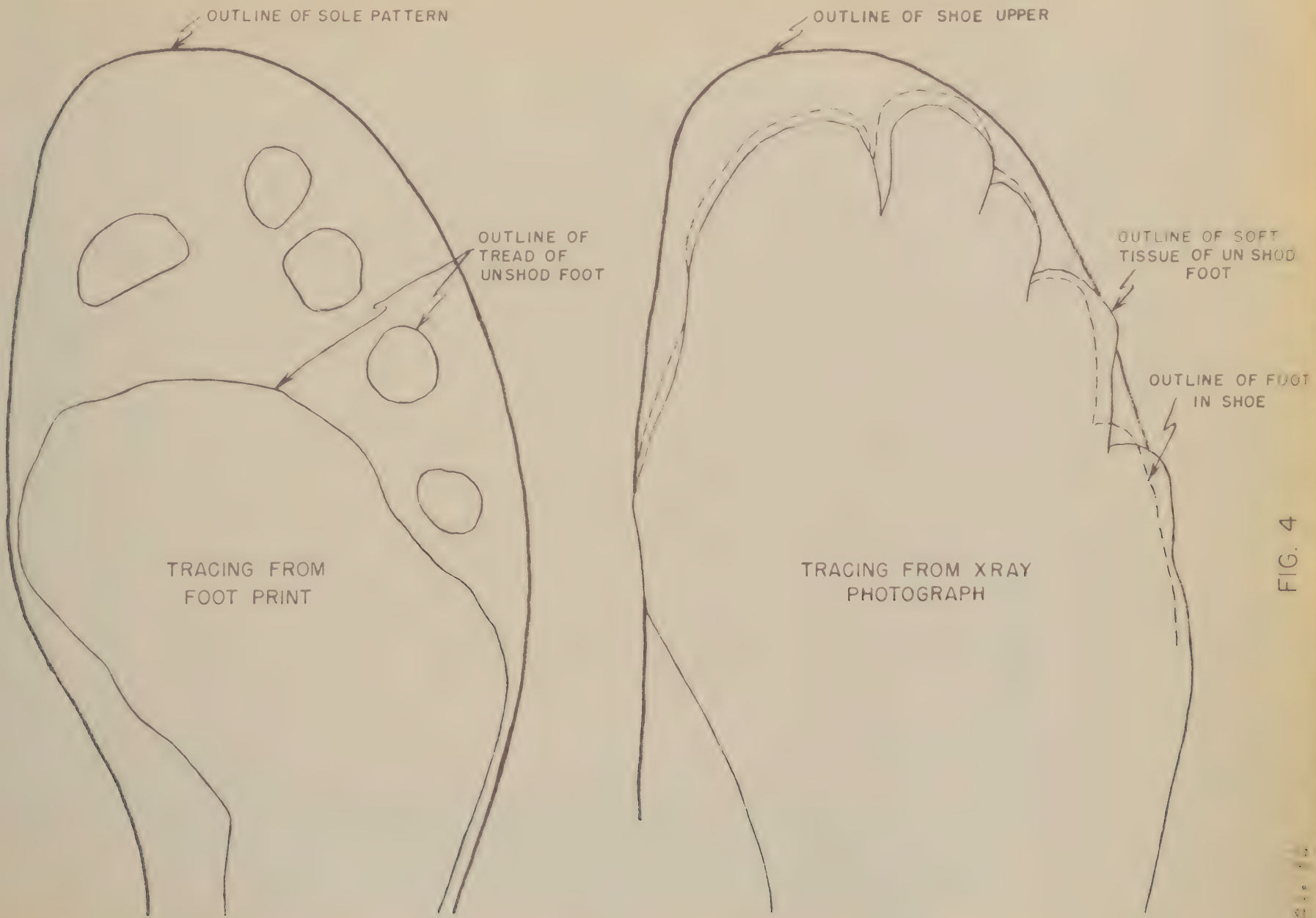
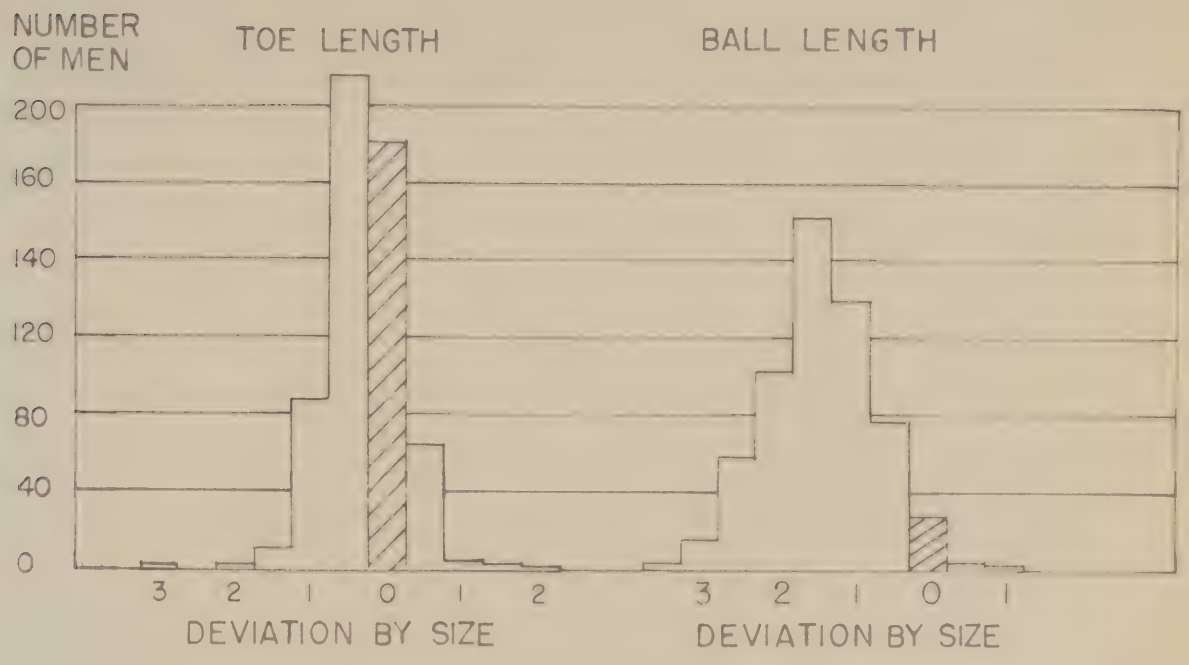


FIG. 4

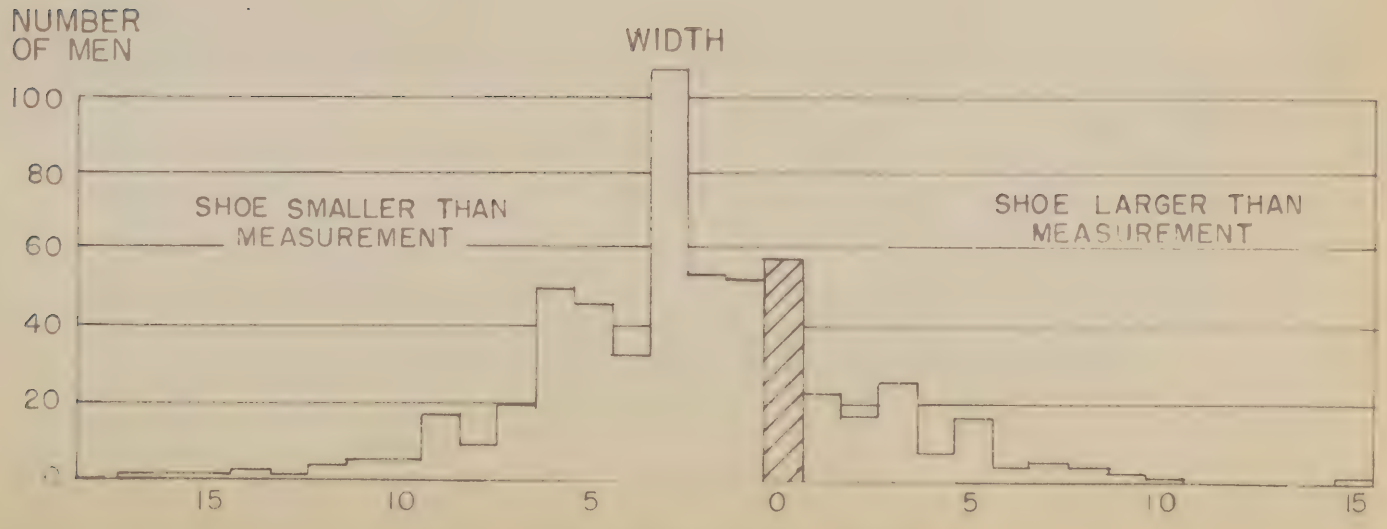
FIG. 5

DEVIATION OF ISSUED SHOE SIZES FROM MEASUREMENTS OF 3 FOOT DIMENSIONS.

MEASUREMENTS OF 579 MEN MADE WITH BRANNOCK DEVICE ON NUDE FEET



EACH $\frac{1}{2}$ SIZE = APPROX. 4 mm



EACH SIZE UNIT = $\frac{3}{16}$" = 4 + mm

FIG. 6

MAGNITUDE OF DIFFERENCE IN SIZE BETWEEN RIGHT AND LEFT FEET

MEASURED NUDE WITH BRANNOCK DEVICE (609 MEN)

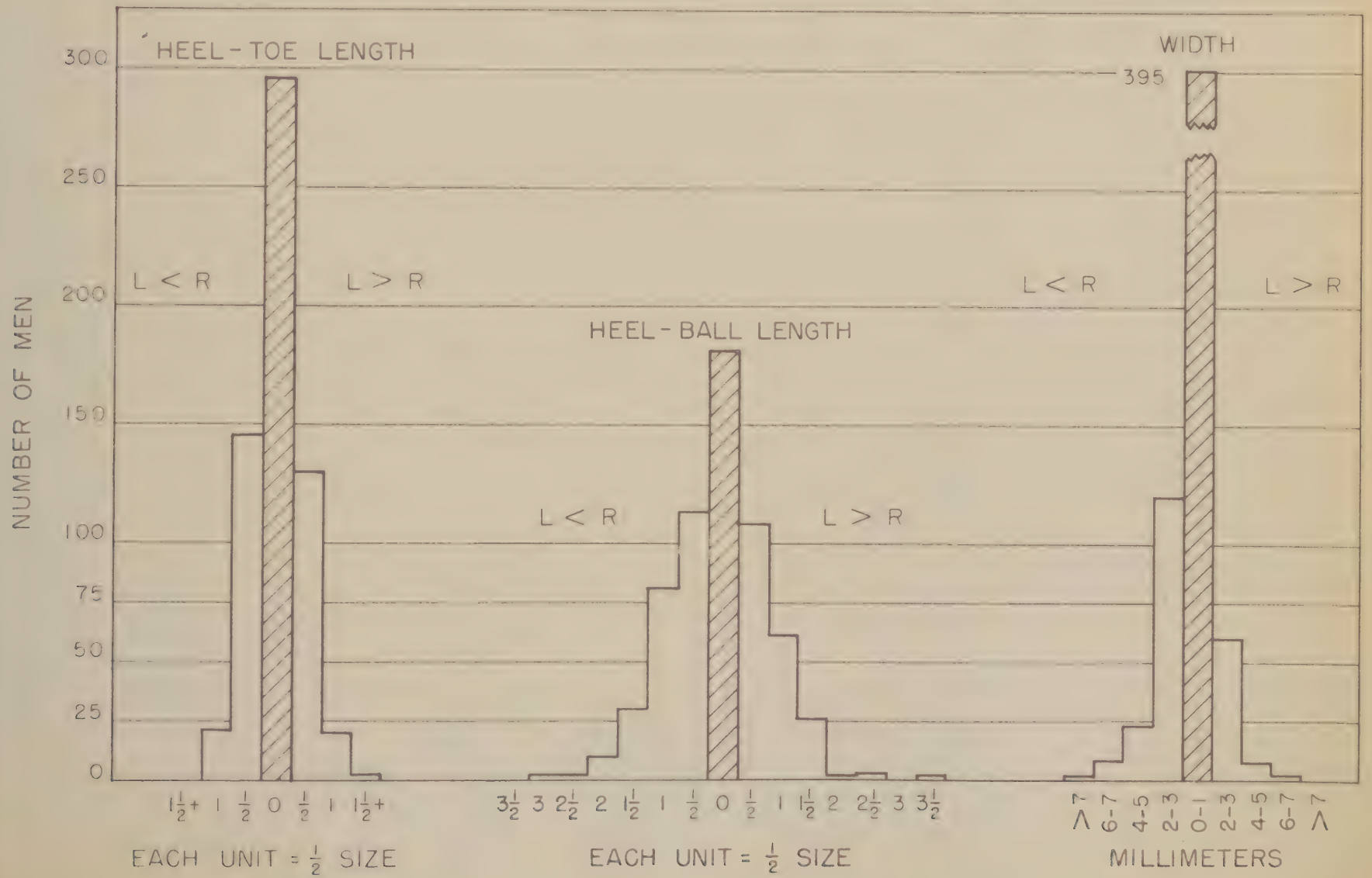


FIG. 6

FIG. 7

MAGNITUDE OF CHANGE IN FOOT SIZE DURING 17 WEEKS BASIC TRAINING AT A.R.T.C. FALL AND WINTER SEASONS

(BRANNOCK DEVICE)
389 MEN

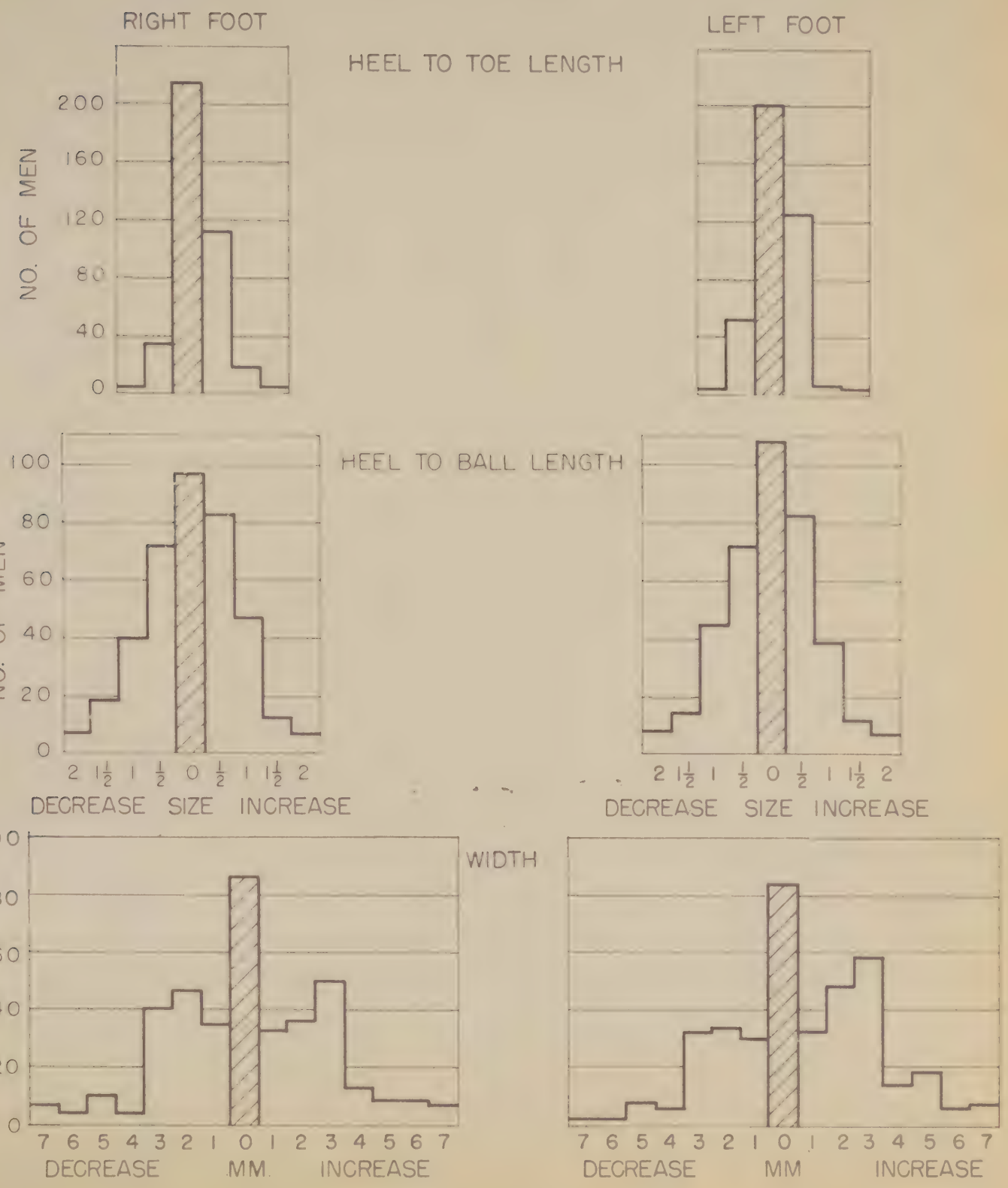
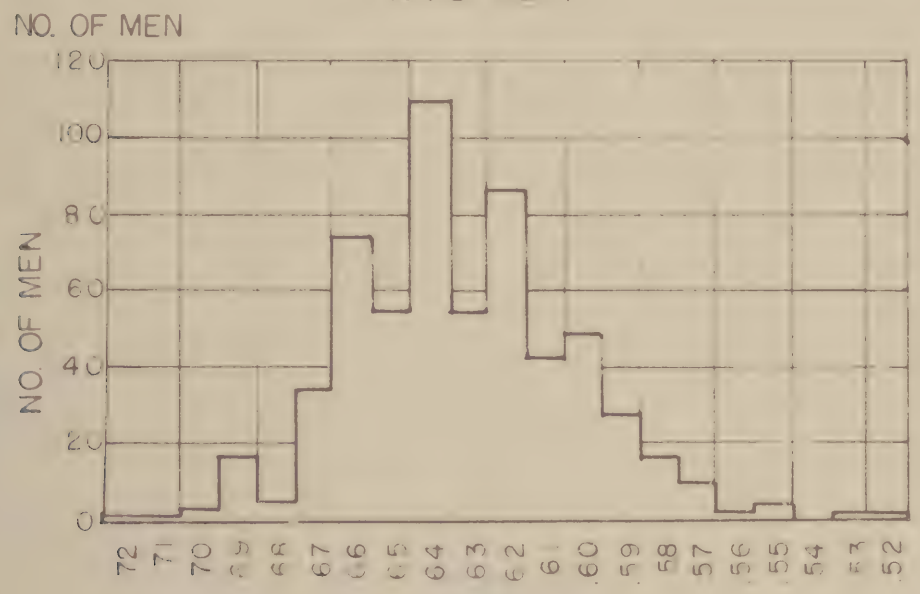


FIG. 8

RATIO OF FOOT LENGTH FROM HEEL TO BALL TO THAT FROM HEEL TO TOE



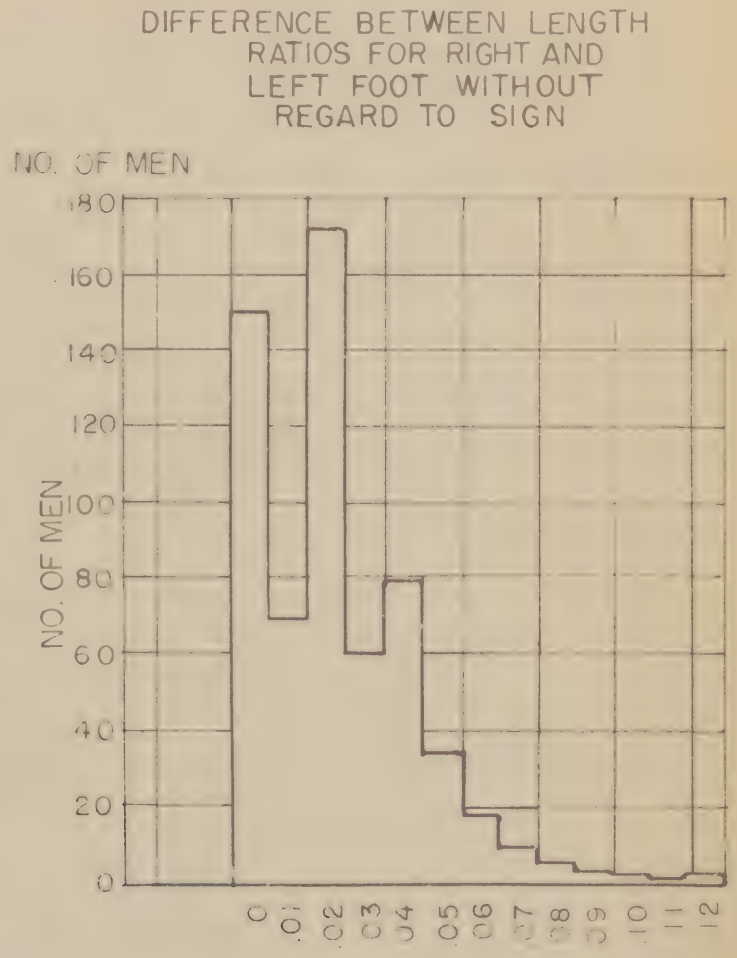
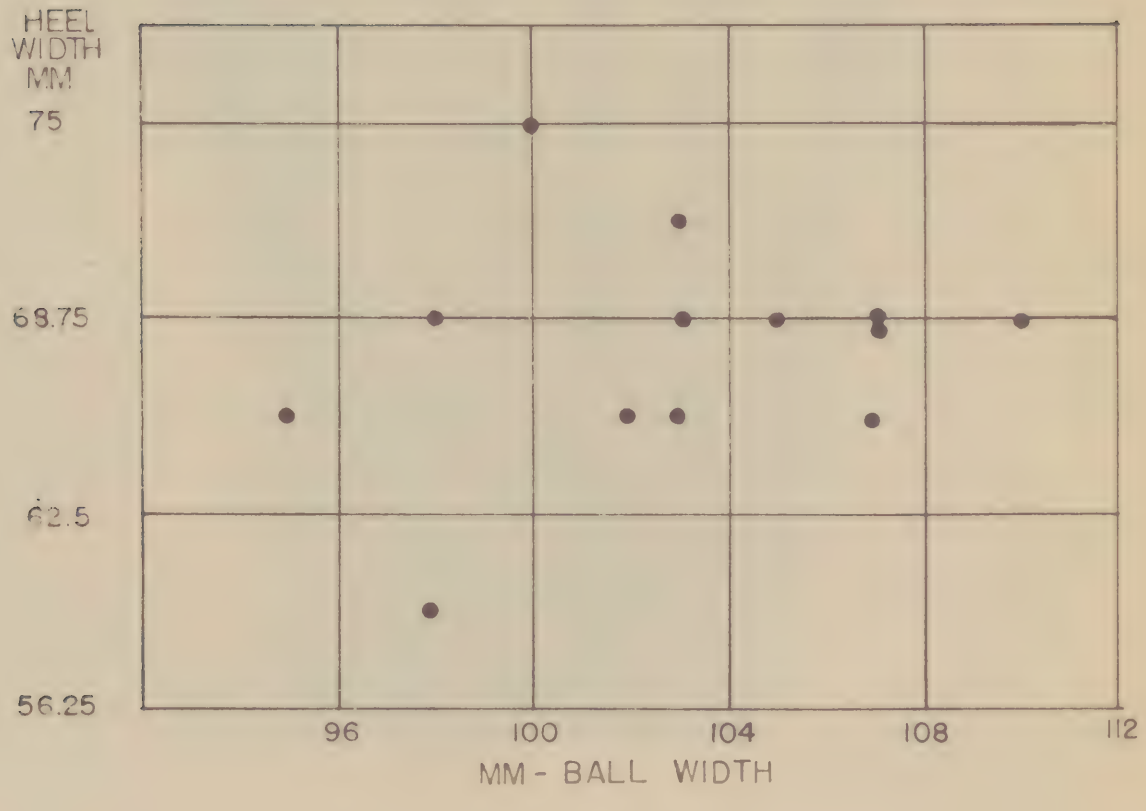


FIG 8

FIG. 9

RELATION OF HEEL WIDTH TO
BALL WIDTH OF 13 MEN



X-ray of Right Foot of Subject Mar
Barefoot
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Subject No. T-10

Photo No. 1

Inc #7

X-ray of Right Foot of Subject Mar
Wearing Shoe Size 9D
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Photo No. 2

Incl #7

X-ray of Right Foot of Subject Mar
Wearing Shoe Size 10½ EE with Sock
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Project No. T-12 Photo No. 3

Incl #7

X-ray of Right Foot of Subject Mar
Wearing Shoe Size 10½ EE without Sock

ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KY.

Project No. T-10

Photo No. 4

Inc #7

X-ray of Right Foot of Subject Man
Wearing Shoe Size 10½ EE with Toe Box Cut Away
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Project No. T-10

Photo No. 5

Jul #7

X-ray of Right Foot of Subject Mar
Wearing Shoe Size 10½ EE with Entire Upper Cut Away
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Project No. T-10

Photo No. 6

Jud #7

Subject Dec
Plaster Model Indicating Natural Contour of Resting Foot - Lateral View
Scale - 1/10"
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.
Project No. T-10 Photo No. 7

Ind #2

Subject Dec
Plaster Model of Interior of Allegedly Comfortable Shoe - Lateral View
Note upward curvature of Toe Segment. Scale - 1/10"
ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.
Project No. T-10 Photo No. 8

Dec #7

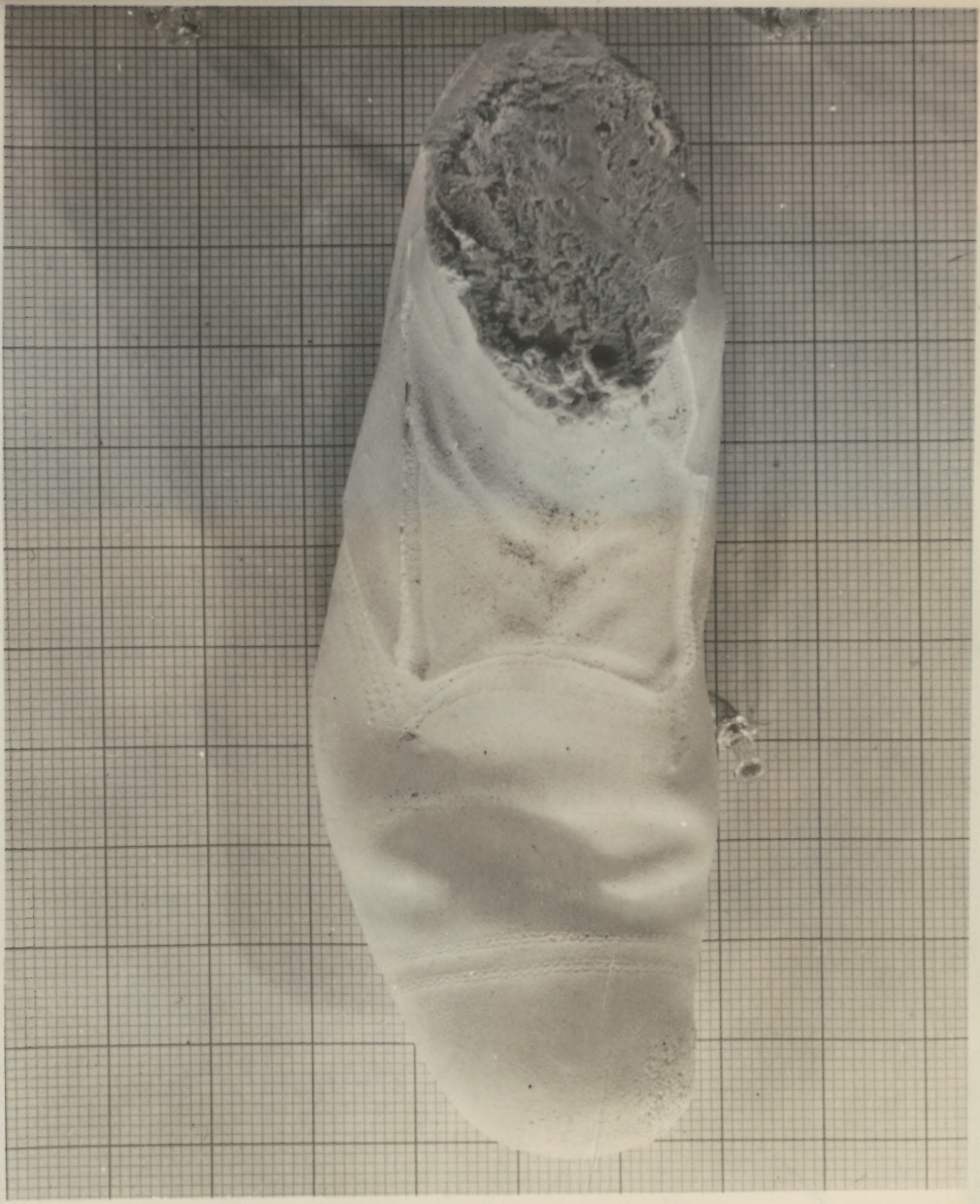
Subject Dec
Plaster Model of Foot - Viewed from Above
Scale - 1/10"

ARMORED MEDICAL RESEARCH LABORATORY
FORT KNOX, KY.

Project No. T-10

Photo No. 9

Jul #7



Subject Dec
Plaster Model of Interior of allegedly Comfortable Shoe - Viewed from Above
Note Incompatibility of Foot and Shoe Contour. Scale - 1/10"

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Project No. T-10 Photo No. 10

Inv #7